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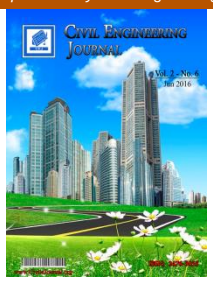

The Methodology of Using Value Engineering in Construction Projects Management

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Abstract

Construction projects are implemented in different countries with heavy costs and some of the projects have been relatively or absolutely unsuccessful and even faced with irreversible losses after construction. Maybe, it is due to complexities related to projects or other social-economic phenomenon. The present study revealed that value engineering can be used as a helpful tool from the beginning of studies to the end of designing, constructing, exploiting, and maintaining processes and overcome civil designs' challenges and complexities. Value engineering is a method experienced in management that has an organized approach. Value engineering has a systematic and cooperative mechanism to analyze function and systems with the aim of achieving desirable function with the least costs. This study has attempted to briefly introduce concepts and executive process of value engineering in construction projects. Also, the study has attempted to investigate conventional methods of evaluating projects function and compare them convergence with value engineering to improve projects. Based on the research findings, it can be found that if we can expect to achieve projects objectives by spending the least cost and ensure the efficacy of investment in construction projects management sector as a main challenge of development plans in the third world countries through using engineering in appropriate time periods and in different phases.

Keywords: Value Engineering; Construction Project; Value Index; Value Analysis; Value Management; Value Methodology.

1. Introduction

Value engineering is a systematic, creativity and team work-based method to solve problem, decrease cost and improve function and quality of projects, goods and processes. Using a wide range of knowledge and specialists' experiences and focusing on the functions of project or process, value engineering presents practical results for rapid improvement. According to international Project Management Institute (PMI), value engineering is a creative perspective to optimize life cycle costs, save time, increase profit, improve quality, increase market share, solve problems, and optimally use resources [1]. According to the definition provided by Association of Project Management (APM), obtaining desirable value requires making balance between contrast parameters to achieve an appropriate situation while value management is facing with strategic issues, optimizing concepts, technical points, executive aspects, and configuring value" [2].

Institute of Value Management of Australia (IVMA) defines value management in construction projects as "an analytical and organized process that attempts to satisfy employer, consultant and contractor by ensuring about necessary functions with the least possible cost and maintaining quality level and function to maximize value [3].

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Using value engineering methodology in early stages of a construction project's conceptual planning is called value planning in projects. In this stage, conceptual designing is unconditioned and value improvement techniques, especially function analysis can be used for optimal and primary selection of design progress [4].

2. Presenting Value Index in Construction Projects Management

In construction projects, value index is a criterion that is used to determine the level of the improvement due to value engineering in a project as well as comparing the improvement level in various projects due to value engineering. In order to determine this index, value index is divided by the improvement due to changes. Construction project cost after the changes is also computed and is placed in the denominator of the fraction. Finally, this fraction equals value index in a construction project [5]. Obviously, higher value of this index leads to higher improvement in the project. According to this definition, value index in construction projects refers to total incomes resulted by (function value) divided by total cost (function costs).

3. Value Engineering Objective in Construction Projects

Value engineering objective in construction projects is to present strategies that can be implemented to solve problems, decrease cost and increase quality (performance) and all these depend on attention to project function; however, the considered objectives in the shortest possible time is very important [6]. Another objective of value engineering is to find optimal point between function, quality and cost in construction projects. In fact, general objective of value engineering is to increase construction project value.

4. The Causes of Using Value Engineering in Construction Projects

Principally, improvement and saving methods are used in case of limitations. Some of the main causes of using value engineering in construction projects include high project implementation cost, high distance between design and implementation, difficult implementation of construction projects, high complexity of construction projects, lack of primary information in construction projects, lack of relations between design and beneficiaries of project in construction projects, advancement of employed technologies and improvement of standards in construction projects, creativity, honest but wrong primary beliefs, changing rules and regulations, changing employer's need, changing environmental, social and economic conditions, changing technical characteristics of design, changing the employed resources.

It should be noted that the improvement due to value engineering is not merely due to lack of adequate study or careless technical and economic investigations but due time interval between design, implementation and operation stages on the one hand, and investigating group creativity and synergy of study group on the other hand. These agents involved lead to the considerable improvement and saving through value engineering in construction projects.

5. Comparing the Methodology of Value Engineering and Other Methods Existing in Construction Projects Management

According to the definition of value engineering, compared to other methods of cost reduction and quality improvement, value engineering advantages include the focus on construction projects functions and making use of group creativity and resulted synergy to present strategies that can be implemented in the lowest possible time. Presenting the tools kit matrix, the present paper compares several management methods and presents a method to evaluate these methods. In this regard, the methodology is based on 5 comparisons. If a method is particularly appropriate for a function, score u is allocated to the method; if it is useful for a function but it is not the main function, the score 4 is allocated to it; if the method is less practical, the score 3is allocated to it, and the scores 1 and 2 indicates inefficiency of the method regarding the considered function [7].

Table 1. Comparing the methodology of value engineering and other methods existing in construction projects management

Comparative matrix	Benchmarking	ZBB	VE	TRIZ	TQC	Target Costing	TAGUCHI	Simulate. Eng.	QFD	MBO	KAIZEN	K-T	JIT	FMEA	DFA	System
Organizing design and de development			5					3		5						A
Developing group cooperation skill			5					4	4	4	5	5				B
Simplification functions			5							3	4					C
Organizing and improving cost			5							5	4		4			D
Improving production cost	4		5	4		5	4	3	4		3	3	4		5	E
Budget control		4				5									4	F
Construction project improvement	4		5	5	5		5	3	5			4				G
Creating new idea	4		5	5					4		5					H
Developing creativity			5													I
Improving project quality			4		5		5		4		5			4		J
Improving project functions	4		5		5	4	5		3		4		5	5	5	K
Improving administrative functions		5	5		5	4		4	3	5			5		5	L
Problem solving			5	5	4		3		4			5			3	M
Information development			4						5							N
Improving project reliability			4		4		5							5		O
Decreasing the number of engineering changes			5						4							P
Accessible software			3	5												Q
Organized process			4	5					5		4	5		4	5	R
Activity0based process	5	4		4	5	5	5	5	5	5	5	5	5		5	S
Function-based process		5	5													T
	22	**18**	**84**	**32**	**33**	**23**	**32**	**22**	**50**	**27**	**39**	**27**	**23**	**18**	**32**	**TOTAL**

6. When Value Engineering Is Used in Construction Projects?

Value engineering can be implemented in all stages of a construction project; however, its highest profit belongs to the preliminary stages of planning and designing the project where employer and designer are more flexible; changes are applied simpler; changes less influence the project, and impose less cost to the project. According to international association of value engineering's standard, the highest profit and saving in resources are developed in the preliminary stages of and obtained during conceptual stages. In this stage, the preliminary project information is created but the main design and development resources have not been yet clear. Therefore, this period of time is the best time of using value engineering, when the situation of actualizing the main function of construction project has not been achieved yet and alternative methods can be determined and considered.

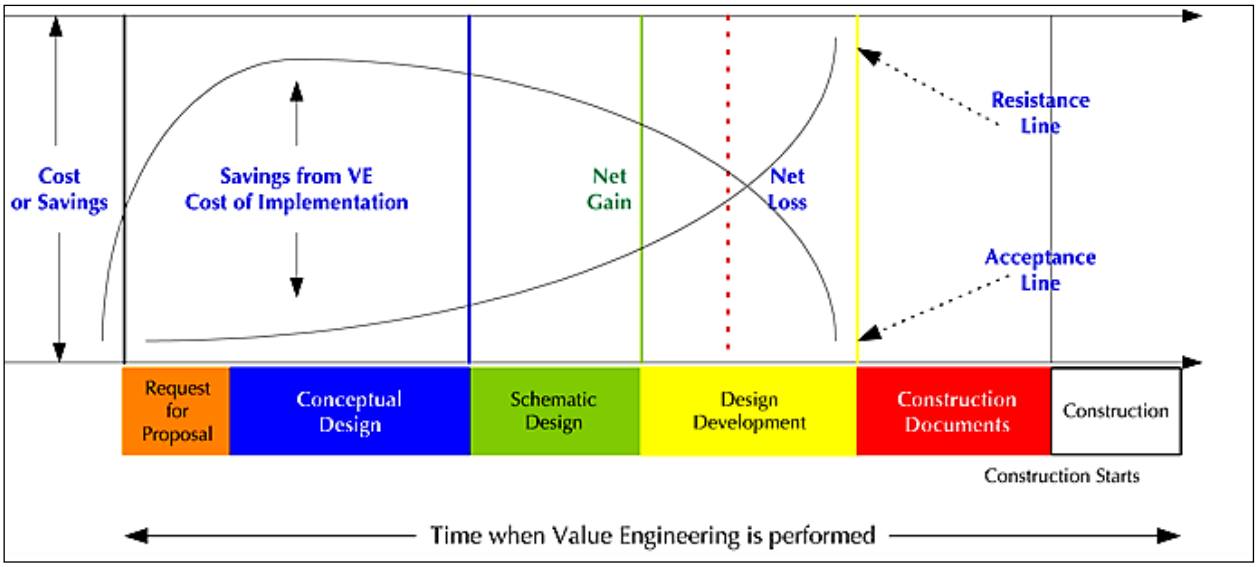

Figure 2. Time when value engineering is performed in construction projects

Value engineering in construction projects can be used more than one time in the project life cycle. The primary value methodology use helps start the project in a proper path and its frequent uses will help modify the project path based on new or changed information [8]. When a value engineering study is performed in the final project development stages, implementation costs will be increased with higher likelihood. Given to the aforementioned, it can be concluded that the closer the starting time of value engineering studies to feasibility study stages is, the higher its effect on the project profits will be.

For value engineering studies in the periods before implementation and construction operations in construction projects, 1 study for small projects (with the cost of 20 to 100 milliard Rials), 2 studies foe medium projects (with the cost of10 to 300 milliard Rials) and 5 studies for large projects (with the cost of 300 to 800 milliard Rials) and very large project (with the cost of above 800 milliard Rials) are proposed such that at least 1 value study is obligatory for all medium, large and very large projects. Table 3 presents the number of the proposed value studies and their implementation time.

Table 2. The definition of construction projects size for value engineering studies

Size of project	Cost estimation
Small	From 20 to 100 milliard Rials
Medium	Above 100 to 300 milliard Rials
Large	Above 300 to 800 milliard Rials
Very large	Above 800 milliard Rials

Table 3. The number of the proposed value studies and their implementation time in construction projects

Size of project	Start	Primary feasibility study	Final feasibility study and primary design	Detailed design			Finished
				25% progress	50% progress	75% progress	
Small	-	-	3-5 days optional workshop	-			
Medium	-	-	3-5 days obligatory workshop		3-5 days optional workshop		
Large	-	3 days optional workshop	5 days obligatory workshop	5 days optional workshop	3-5 days optional workshop	3-5 days optional workshop	-
Very large	-	3 days obligatory workshop	5 days obligatory workshop	5 days optional workshop	3-5 days optional workshop	3-5 days optional workshop	-

7. Barriers of Unsuccessful Use of Value Engineering in Construction Projects

The barriers of using value engineering or the causes of its failure in construction projects included the following:

- Lack of belief, lack of accepting design agents involved particularly construction projects employer
- Wrong imagination of obtaining improvement and decreasing cost through improper design and lack of adequate studies by design consultant in construction projects
- The resistance of designer and consultant of construction projects against accepting to investigating design through value engineering due to the imagination of insulting to own specialist place
- Lack of belief of design agents involved particularly contractors in value engineering process due to unsuccessful experiences of other methods decreasing cost and improving design or construction process

- Lack of adequate motivation of the project design's agents involved to improve construction projects design

8. Presenting Value Engineering Methodology in Construction Projects Management

Value engineering process in construction projects is performed in three phases: pre-study in construction projects, the value study in construction projects, and post-study in construction projects (complementary studies). Each of these three phases in construction projects is divided into important activities which are discussed in the following.

8.1. Pre-Study Stage in Construction Projects

The purpose of this stage is to plan and organize value study in construction projects. Some activities necessary to achieve this objective include:

- gaining the approval of senior manager and supporting work plan, roles and responsibilities in construction projects,
- developing value study range and objectives
- obtaining project data and information
- obtaining key documents such as the definition of work range, maps, characteristics, reports, and evaluating construction project
- determining and prioritizing considered strategic problems
- determining the range and objectives of study
- Developing time schedule in construction projects
- Competitive benchmarking analysis
- Determining value team members
- Obtaining the selected members commitment to achieve the project objectives
- Investigating the project costs
- Gathering information required by employer/consultant/executor regarding the project
- Inviting suppliers, customers, and beneficiaries to participate in value study (if necessary)
- Distributing information among team members for investigation
- Developing informational charts and models of the project
- Determining time and place and other requirements of the study
- Providing a clear definition about the study requirements with senior management to achieve successful value study results

Desirably, this stage is resulted in a clear understanding about senior management needs, strategic priorities and the way of increasing organizational value through improvement. During this stage, this view is formed that whether the next phases create adequate value to justify the study cost. Maybe, there is a need of increasing or decreasing the study parameters. Team members are informed about the project objectives and are committed to achieve them [9].

8.2. Value Study Stage in Construction Projects

8.2.1. Information Phase

The purpose of this phase is to understand and define the status quo of the project and limitations influencing the project results as well as determining the study objectives. Some necessary activities to achieve this objective include:

- Obtaining key documents such as the definition of work range, maps, characteristics, reports, cost information details of the project, qualitative data, marketing information, process flow charts, etc. To this end, some tools such as quality function development (QFD) and voice of customer (VOC) can be used.
- Determining and prioritizing the considered strategic problems and also defining the range and objectives of the study (management's expectations). To this end, some tools such as SWOT analysis (strength, weakness, opportunity, and threat) and the project charter can be employed.
- Presenting the main design or the concepts of design/construction/process by the project team
- Competitive benchmarking analysis. In this regard, benchmarking, disassembly analysis, Pareto analysis, and design for assembly are used.
- Determining time schedule of the study including time, place and other requirements
- Distributing information among team members for investigation

- Understanding the range, scheduling, costs budget, risk, problems, and non-financial performance of construction project
- Confirming the design based on the main construction project
- Determining high level functions of construction project
- Field visits of the site or installation place

Consequently, this phase provides all team members with a general and basic perception about construction project including tactical and operational issues and the study subject features.

8.2.2. Function Analysis Phase

The purpose of this phase is to functionally understand the project; that is, what the project should do instead of who the project is now? Some activities necessary to achieve this objective in construction projects include:

- Determining the project functions through tools such as random functions determination
- Classifying the project functions
- Developing the function model by tools such as function analysis system technique (FAST)
- Evaluating mode by cost parameters, performance characteristics and user behaviour to select functions nonconforming value to focus on creativity phase. The employed tools include cost-function analysis (function matrix) and performance-function analysis
- Estimating functions' cost to select functions nonconforming value and the focus of creativity on them by a tool such as value index (function cost divided by function price)

This phase causes that team focuses on actualizing the project employer's needs and objectives. Additionally, a more comprehensive understanding about the project is created and finally, the functions nonconforming value to focus on them in order to improve construction projects is specified by the team.

8.2.3. Creativity Phase

The purpose of this phase is to present a number of ideas regarding other methods of actualizing functions. Some activities necessary to achieve the objective of this phase in construction projects entail:

- Performing creativity preparation practices
- Using some rules providing creativity atmosphere such as ground rules
- Using techniques encouraging group ideation
- Generating alternative idea with the possibility of improving value through techniques such as brain storming, Gordon technique, nominal and Therese techniques

Then, the team develops a list of idea providing a wide range of possible alternatives to actualize functions with the purpose of improving construction projects value.

8.2.4. Evaluation Phase

The purpose of this phase is to decrease the number of ideas and present a short list of most potential ideas to improve and actualize the project functions with respect to qualitative requirements and resources limitations. Some activities necessary to achieve the objective of this phase in construction projects involve:

- Explaining and classifying each of ideas to create a common understanding
- Discussing about the effect of ideas on performance and cost parameters using T-chart
- Selecting and prioritizing ideal for more development through Pugh analysis, Kepner-Tregoe, life cycle costing (LCC), choosing by advantage (CBA), and value standard
- Explaining the way of recording ideas as stand-alone risk-reward investment proposals

The team provides a concepts-focused list that guarantees quality time to develop value-oriented solutions that can be implemented in one or a combination of projects.

8.2.5. Development Phase

The purpose of this phase is to more investigate and develop a short list of ideas and properly develop them to select alternative values. Some activities necessary to achieve the objective of this phase in construction projects include:

- Comparing the study results regarding success requirements confirmed during information and function analysis phases

- Providing a documentary value alternative for each of idea selected for higher development
- Evaluating and considering risk and cost judgments, if needed
- Performing cost-profit analysis
- Providing designs and requirements required to transfer concepts
- Confirming the necessity of the need of more developing an alternative
- Providing an executive design to define implementation stages, dates and responsibilities for each of value alternatives

The value study team creates alternative scenarios with low, average and high risk and present them to senior manager as the choices specifying strategic pre-workshop objectives.

8.2.6. Presentation Phase

The purpose of this phase is to present value alternatives to management team and other beneficiaries or decision makers of construction project. Some activities necessary to achieve the objective of this phase in construction projects involve:

- Providing and presenting supporting documentaries
- Comparing the results of study on successful requirements confirmed during information and function analysis phases
- Proposing stand-alone risk-reward investment scenarios to manger to select value alternatives to implement
- Exchanging information with the team
- Ensuring about adequate information of manger for decision making
- Providing executive maps drafts summary
- Providing formal report: The usual results of value study include justifying documents, risk analysis, cost and price comparisons, present value analysis, and advantage-disadvantages.

8.3. Post-Study Activities in Construction Projects

8.3.1. Implementation Phase

The purpose of this phase is to ensure the applicability of the confirmed value alternatives and actualizing and confirming the planned advantages of value study. Some activities necessary to achieve the objective of this phase in construction projects involve:

- Investigating primary report
- Holding meeting with the subject of implementation to determine each value alternatives formation
- Creating executive designs for the confirmed alternatives and documenting the main rejected alternatives causes
- Obtaining implementation warranty for construction projects
- Determining a time interval to investigate and implement each of value alternatives
- Pursuing value achievements resulted by the implemented alternatives
- Submitting deliverables
- Confirming the credit of the performed changes benefits
- Ensuring about considering new experiences by creating and managing an executable design

Construction projects beneficiaries determine which items should be changed as the study result. These changes are the primary concepts of the basic design of a study that are resulted from value alternatives and are combined to develop project in future plans or project development activities.

8.3.2. Tracking Activities of Value Study

The purpose of tracking activities is to follow up implementing value study results and improve value methodology for future studies in similar construction projects. Some activities necessary to achieve the objective of this phase in construction projects entail:

- Providing a report of the study results, previous learned lessons, or other recorded or tracked cases in construction project implementation
- Determining missed opportunities
- Specifying innovation barriers and finding their causes

- Obtaining information and recorded learned lessons
- Integrating value study results with learned lessons or organization report
- Returning to value study and thinking about the way of developing experience with new capabilities in construction projects

Returning to their opinions before value study and comparing the method of achieving subjects and proving the effect of knowledge on their belief in their primary opinions, individuals become better value creators for construction projects. This important phase seeks to make organizations better in innovation management.

8.4. Presenting Secondary Advantages of Using Value Engineering in Construction Projects

In addition to its main advantages such as improving design quality and decreasing cost, value engineering is followed by other advantages which are as following:

- Creating synergy in organization
- Improving communications among design's involved persons
- The possibility of using applicable ideas in similar projects
- Increasing team work spirit in organization
- Familiarity of project's involved persons with function-oriented useful thinking
- Promoting creative and deconstructing thinking

9. Conclusion

In the present paper, it was attempted to present a methodology to use value engineering in construction projects management. The importance of the discussed issue is achieving a new view about planning construction projects and generalizing constriction management knowledge. As the advantages of the proposed methodology is to identify employer/consultant and executor's principal demands in construction projects, leading to the stages of more efficient planning, designing and constructing. It seems that using such approaches by companies involved in large construction projects not only causes an evolution in qualitative and quantitative results but it creates prosperity in business space and even provides engineering services at international level. However, there is a further study on explaining physical components in details and testing it for various construction projects with various domains, sizes sensitivities, and contracts.

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